Claims

We claim:

1. An integrated circuit including a multi-layered barrier metal thin film structure, comprising:

a substrate;

a barrier metal thin film deposited on said substrate by the process of atomic layer chemical vapor deposition, wherein said barrier metal thin film comprises a metal nitride; and

a thin copper film deposited on said barrier metal thin film.

2. The integrated circuit of claim 1 wherein said barrier metal thin film defines a thickness in a range of 50 to 100 Angstroms.

3. The integrated circuit of claim 1 wherein said barrier metal thin film defines a thickness equal to an atomic thickness of said metal nitride.

4. The integrated circuit of claim 1 further comprising a second barrier metal thin film positioned between said barrier metal thin film and said thin copper film, wherein said second barrier metal thin film is deposited on said barrier metal thin film by the process of atomic layer chemical vapor deposition.

5. The integrated circuit of claim 4 wherein said barrier metal thin film and said second barrier metal thin film are each chosen from the group consisting of TiN, TaN, W, WN and Si_3N_4.

6. The integrated circuit of claim 1 wherein said thin copper film remains adhered to said barrier metal thin film during standard tape and peel tests.

7. The integrated circuit of claim 1 wherein said substrate comprises a trench having a bottom surface and a side wall, and wherein said barrier metal thin film is deposited on said bottom surface and said side wall by atomic layer chemical vapor deposition such that said barrier metal thin film defines a blocking diffusion characteristic which is the same on said side wall and said bottom surface.

8. A method of manufacturing a multi-layered barrier metal thin film by atomic layer chemical vapor deposition, comprising the steps of:

providing a substrate in a reactant chamber;

providing a first chemical species in said reactant chamber;

providing a second chemical species in said reactant chamber, wherein said first and second chemical species react to deposit a barrier metal thin film of a metal nitride on said substrate by atomic layer chemical vapor deposition, wherein said barrier metal thin film deposited on said substrate defines a thickness of less than 100 Angstroms.

9. The method of claim 8 further comprising depositing a thin copper film on said barrier metal thin film.

10. The method of claim 8 wherein said thickness of said barrier metal thin film is equal to an atomic thickness of said metal nitride.

11. The method of claim 8 further comprising providing a third chemical species in said reactant chamber and providing a fourth chemical species in said reactant chamber, wherein said third and fourth chemical species react to deposit a second barrier metal thin film of a metal nitride on said barrier metal thin film by atomic layer chemical vapor deposition.

12. The method of claim 11 wherein said barrier metal thin film and said second barrier metal thin film are each chosen from the group consisting of TiN, TaN, W, WN and Si_3N_4.

13. The method of claim 8 wherein said substrate comprises a trench having a bottom surface and a side wall, and wherein said barrier metal thin film is deposited on said bottom surface and said side wall by atomic layer chemical vapor deposition such that said barrier metal thin film defines a blocking diffusion characteristic which is the same on said side wall and said bottom surface.

14. A method of manufacturing a multi-layered barrier metal thin film by atomic layer chemical vapor deposition, comprising the steps of:

providing a substrate in a reactant chamber;

providing a first chemical species in said reactant chamber;

providing a second chemical species in said reactant chamber, wherein said first and second chemical species react to deposit a first barrier metal thin film of a metal nitride on said substrate by atomic layer chemical vapor deposition;

providing a third chemical species in said reactant chamber;

providing a fourth chemical species in said reactant chamber, wherein said third and fourth chemical species react to deposit a second barrier metal thin film of a metal nitride on said first barrier metal thin film by atomic layer chemical vapor deposition.

15. The method of claim 14 wherein said method is conducted at a temperature in a range of 300 to 600 °C, at a pressure in a range of 0.001 to 1.0 torr, and wherein each atomic layer chemical vapor deposition step is conducted for a time period in a range of 0.4 to 5.0 seconds.

16. The method of claim 14 further comprising providing a fifth chemical species in said reactant chamber and providing a sixth chemical species in said reactant chamber, wherein said fifth and sixth chemical species react to deposit a third barrier metal thin film of a metal nitride on said second barrier metal thin film by atomic layer chemical vapor deposition.

17. The method of claim 14 further comprising depositing a thin copper film on said second barrier metal thin film.

18. The method of claim 14 wherein said first barrier metal thin film and said second barrier metal thin film are each chosen from the group consisting of TiN, TaN, W, WN and Si_3N_4.

19. The method of claim 14 wherein said first barrier metal thin film and said second barrier metal thin film together define a layered structure having a thickness of less than 60 Angstroms.

20. The method of claim 14 wherein said first chemical species comprises a metal halide and said second chemical species comprises a nitrogen containing gas.